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Evaluating The Feasibility And Effectiveness Of Self-Monitoring Of Health – A Pilot Study Among Samoan Women

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Abstract

Background:
Samoa, like many low- and middle-income countries, faces a high burden of obesity and non-communicable disease. Self-monitoring technologies to help individuals track their health have proven effective in high-income countries, but have not generally been tested in low-income settings. To investigate the feasibility and potential effectiveness of using step-counters and digital scales in Samoa, we conducted a pilot randomized controlled trial.

Methods:
The trial enrolled 44 Samoan women (31-40 years) without chronic conditions (non-hypertensive, non-diabetic, etc.) and who reported motivation to become more active. After a 1-week baseline period to measure physical activity in the absence of any feedback, participants were randomly assigned for the 4-week intervention period to 1 of 3 groups: 1) using a FitBit Zip step-counter, 2) using a digital BodyTrace scale, or 3) using a FitBit and scale. Outcomes of interest were device use, psychosocial indicators of health, daily step counts, and body mass index (BMI), measured at baseline and following the intervention.

Results:
While Fitbits were used a majority of days during the baseline period, there was a significant decline in device use during the intervention period. Participants who received scales used them a median of 5.5 times over the 4-week intervention period. All groups improved in their assessment of Health Locus of Control, Self-efficacy for Exercise, and Weight Efficacy. However, while the FitBit Only group reported improved health related quality of life, the two groups that used scales either did not significant change or reported a significant decrease in their assessments of this measure. The two groups using scales also significantly increased their BMI. No group demonstrated change in average daily step counts during the intervention.

Discussion:
Results suggest that self-monitoring technologies are acceptable in Samoa and have potential influence on psychosocial indicators of health. Further research is necessary to assess their effectiveness as an intervention tool and to determine how best to sustain device use over time. The significant increase in BMI over the relatively short intervention period highlights the importance of developing effective intervention approaches in this setting.

Keywords: Chronic Disease Epidemiology, Samoa, health behavior change, self-monitoring

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Background

The rising burden of non-communicable diseases (NCDs) disproportionately affects low and middle income countries (LMIC); 78% of annual global NCD deaths and 85% of premature deaths due to NCDs occur in LMICs [1]. The global epidemic is especially severe among Pacific Islanders and in Samoa. A 2010 study estimated that 64.6% of adult women and 41.2% of adult men in Samoa were obese, according to Polynesian BMI cut offs (BMI $\geq$32 kg/m^2).[2,3] The high prevalence of obesity has arisen as Samoans have progressed in the nutrition transition. Through this process, traditionally active lifestyles and diets of native fish and produce have been replaced with increased sedentarism sedentary lifestyle and diets reliant on imported and processed foods.[4,5] When combined with genetic factors and cultural values, these new patterns of energy intake and expenditure have contributed to the high levels of obesity observed today.[6-9] However, although Samoan culture has traditionally valued sedentary behavior as a sign of high status, recent evidence suggests a shift towards Western ideals of health and physical activity.[8,9] Addressing the high burden of obesity in Samoa requires new and innovative approaches that encourage the adoption and maintenance of health behaviors, such as healthy diet and physical activity.

Previous studies conducted in high-income settings have found that self-monitoring of diet, weight, and physical activity is a key component of effective behavior change and weight control interventions.[10-12] Self-monitoring of health is a broad approach that encompasses a variety of strategies, ranging from keeping a paper diary of behaviors to utilizing high-tech tracking devices including pedometers, used to track walking behaviors. These devices are low-tech, affordable, and provide a clear, easily understood output for users, usually their step count.[13] This output can be helpful in making participants aware of their level of physical activity and helping them to track their progress toward goals. A systematic review of studies that were conducted exclusively in high income countries found that participants who used pedometers to track their physical activity for an average of 18 weeks increased their physical activity by 26.9% over baseline.[14] Of the included interventions, some introduced individualized step goals, some another activity related goal, and some asked individuals to track their physical activity without introducing specific goals.

The self-monitoring approach has also been applied to weight. Previous research has shown that individuals tend to underestimate their own weight, which is a potential barrier to health behavior change.[15,16] Self-weighing has been identified as a key aspect of weight control interventions because it improves participant awareness of their own weight and encourages them to place fluctuations in weight in the context of their energy intake and expenditure. A systematic review of studies conducted in the United States found that more frequent self-weighing was associated with weight loss, especially for participants who weighed themselves at least weekly.[17] Advances in technology have enabled individuals to set their own weight-related goals and track their progress over time through the use of digital scales that upload data to mobile applications and other web-based platforms.[12]

Despite the success of self-monitoring approaches and technologies in high income countries, the acceptability and effectiveness of these interventions in LMICs is still unknown. However, advancements in web-based platforms and mobile apps make innovative self-monitoring technologies increasingly accessible and promising in these settings. In 2018, an estimated 96% of the world population lived within the reach of a cellular network and 60% of individuals in low income countries had access to a mobile phone.[18,19] Given the confluence of the need for intervention and the widespread accessibility of this technology, we sought to investigate in a randomized trial pilot study the feasibility and potential effectiveness of using step-counters and digital scales in Samoa as a means of health self-monitoring health, increasing daily steps, and influencing BMI.

Methods

Setting

Samoa is a small island nation located in Polynesia. The population of 196,440 is concentrated on the island of Upolu, with a majority living in and around the capital city of Apia.[20] With a Gross National Income (GNI) per capita of US $4090.0, Samoa was recently re-classified by the World Bank as an upper-middle income country.[21] As of 2014, 96.8% of the population had access to a mobile phone.[22]

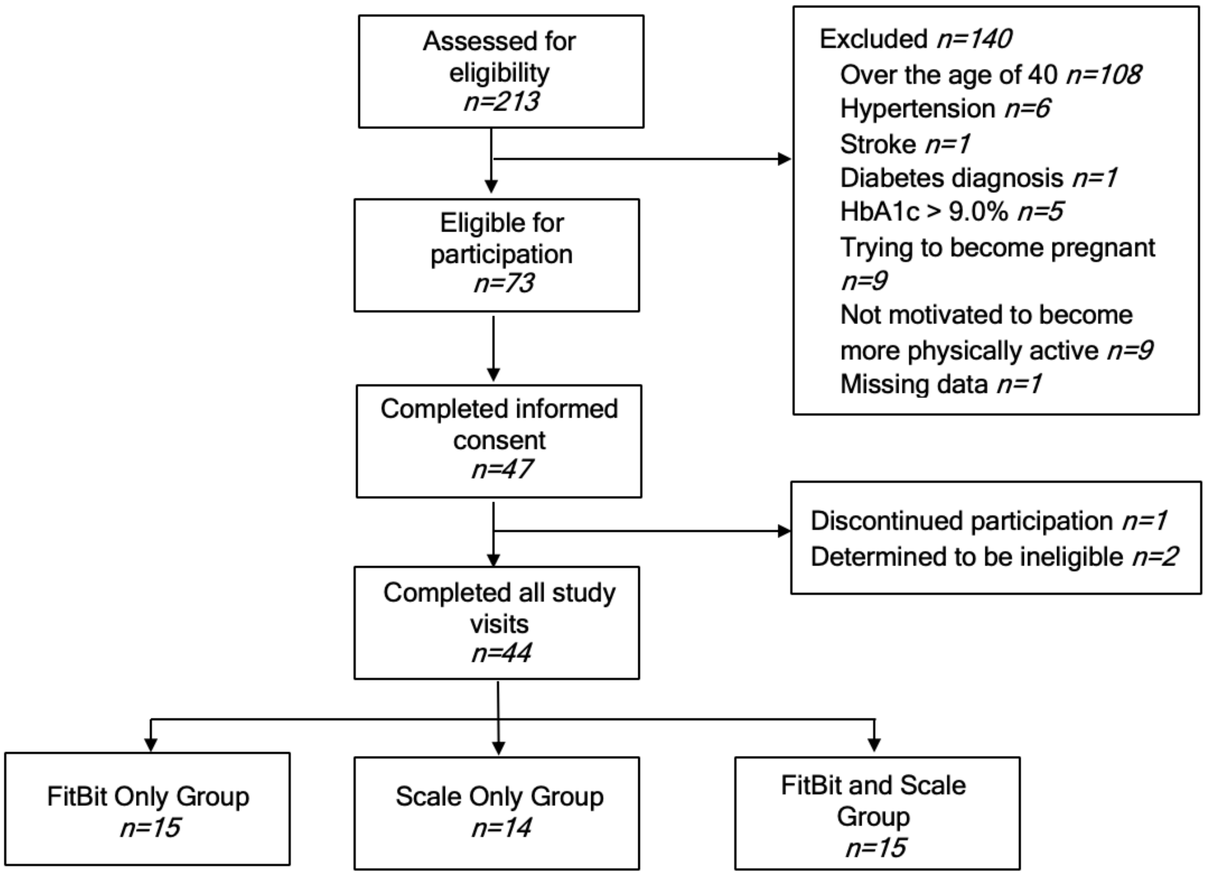
Recruitment

Participants eligible for this study were identified through their participation in the '*Soifua Manuia'* ('Good Health') Energetics study, which was designed to examine the relationship between genetics, energy balance, and obesity in Samoa. The study recruited a total of 699 male and female participants by convenience sampling in 12 villages across the island of Upolu between June and August 2018. Eligible participants were 31 to 50 years of age. Exclusion criteria included: pregnancy, weight loss medication usage, recent instigation of a new diet or exercise program, and/or weight loss of at least 5% of their body weight in the last year. Data collected included demographic and health surveys, anthropometrics, a check of blood pressure and glycated hemoglobin (HbA1c), and a saliva sample for genotyping. During the informed consent process for this screening participants agreed to be contacted about participation in future research studies.

Eligibility for this pilot study was determined based on data collected in the larger study. Women that were between the ages of 31 and 40 years old, reported motivation become more physically active (defined by the Physical Activity Stages of Change questionnaire)[23], not actively trying to become pregnant, and with no medical condition preventing physical activity or making participation inadvisable were included in the study. The age-range was limited to control for age between the intervention groups. Excluded medical conditions were defined by self-report of doctor diagnoses and included: hypertension, heart attack, heart disease, stroke, Type 2 diabetes, non-skin cancer diagnosis, and dialysis. Participants were also excluded if they had severely uncontrolled Type 2 diabetes (HbA1c ≥9.0).

Participants were recruited from the 4 villages in close proximity to the Apia Urban Area to facilitate follow up. Of the surveyed participants in these 4 villages, 213 were women between the ages of 31-40 who were assessed for eligibility and 73 met the criteria for participation (Figure 1). These participants were contacted by members of the research team about participating in an additional research study and further assessed for eligibility. Participants were excluded if they self-reported that they had been hospitalized for depression in the last year, were being treated for psychiatric conditions other than depression, had been previously diagnosed with an eating disorder, or were unable to walk half a kilometer without stopping. No participants were excluded based on these additional eligibility criteria. All explanations of the study and the informed consent process were conducted in Samoan by a trained research assistant. In this explanation, it was made clear that participation in this pilot study was voluntary and unrelated to the ongoing study from which they were originally recruited.

Figure 1: Consort Diagram



Equipment

Two types of devices were utilized to monitor health behaviors in the study: FitBit Zip® activity monitors (Fitbit Inc, USA), and BodyTrace scales.[24] FitBit Zips are electronic, waist-worn pedometers that measure daily step count. The FitBit displayed daily step counts to the participant; upon syncing by researchers via Bluetooth and the mobile-based app, data was also made available to the research team, who retained access to the internet-based tracking accounts. The BodyTrace scales record and display values to the participant and also transmit measurements to an online database through cellular networks. The record of all measurements taken on the scale allowed for analysis of participant use.

Intervention

On the day of enrollment into the study all participants began a 1-week baseline assessment period. They received a FitBit Zip with the screen covered to prevent their behavior from being influenced by the step count data, and were asked to wear the device daily to establish their baseline physical activity. Upon completion of the baseline assessment, participants' weight was measured to calculate their pre-randomization body mass index (BMI). Participants also completed a questionnaire to assess psychosocial indicators of health. The Multidimensional Health Locus of Control Scale (HLOC) was used to measure perception of the influence of three difference potential sources of control on health: the 'internal' scale reflects perceived control health, the 'chance' scale the influence of random chance or luck, and 'powerful others' the influence of people such as friends, family, and medical providers.[25] A higher score on each subscale indicates a greater perceived influence of this locus of control on health. The Self-efficacy for Exercise Behaviors Scale and the Weight Efficacy Life-Style Questionnaire assessed individuals' beliefs about their ability to adopt and maintain health behaviors related to exercise and diet in the face of obstacles, including stressful life events and familial obligations.[26,27] Higher scores on these scales indicate greater self-efficacy. The SF8 Quality of Life scale asked individuals to assess their physical and mental health over the last month, with a higher score indicating a more positive health related quality of life. Finally, a self-reported health question asked individuals to assess their overall health for their age. Potential responses included: Excellent, Very Good, Good, Poor, and Very Poor.

Participants were randomly assigned to one of three intervention groups, defined by the types of feedback they received: 1) FitBit Only (n=15), 2) Scale Only (n=14), and 3) FitBit and Scale (n=15). All participants had FitBits to measure their physical activity, but only participants in the FitBit Only and FitBit and Scale groups could see their step counts. Participants in the Scale Only group continued to use the FitBit with the screen covered so that the only feedback that they received was from the scale. Participants used their given devices for a 4-week intervention period. Because the primary purpose of the study was to explore how participants in this setting viewed and made use of these devices, participants were taught how to use the devices, but were not provided with specific targets related to daily step counts or weight. The research team visited participants once at approximately the midpoint of the intervention period to download data from their FitBits but this visit did not include any additional surveys.

At the end of the intervention period, participants repeated the questionnaire and physical measurements. Upon completion, participants received approximately USD$12 in cell phone credit to compensate them for their time. Participants were also able to keep the FitBit Zip that they used during the study. Individuals in the Scale Only group had the tape removed from their FitBit and were shown how the device screen worked.

Analysis

All analyses were conducted in SAS version 9.4 (SAS Institute Inc., Cary, NC.). Given the small sample size of this study, analysis was conducted using nonparametric methods including Fisher's exact tests for categorical data, the Kruskal–Wallis test for comparisons of the intervention groups, and the Wilcoxon Signed-Rank test for comparisons of measures between the baseline and feedback periods.

FitBit use was defined as the proportion of days in the given period that the individual participant wore the FitBit. A day of use was defined as the FitBit recording more than 100 steps to ensure the step count was not reflecting accidental movement or transport while not being worn. An individual's daily step count for a period of time was averaged over the days that they used the FitBit. Participants were excluded from the step count analysis if they were missing data for an entire week, either due to non-adherence, losing the FitBit, or device malfunction.

Scale use was defined as the number of measurements that an individual made on the BodyTrace scale during the 4-week intervention period. All measurements taken on the scale were downloaded from the BodyTrace database. To identify the measurements that were taken by the participant as opposed to another individual in the household, a consensus approach was taken. Two reviewers assessed the measurements independently and met to resolve any conflicts. Measurements were determined to be the participant based on their initial weight, their weight gain trajectory, and the feasibility of weight change over time. Measurements were included as belonging to the participant if they were within 3 kg of the previous measurement.

Results

Sample Characteristics

A total of 44 participants were randomly assigned to an intervention group (FitBit Only, n=15; Scale Only, n=14; Scale & FitBit, n=14) and completed all of the study visits. Of the three participants who enrolled in the study but did not complete all visits, two withdrew prior to randomization and one withdrew following randomization to the Scale Only group. There were no significant differences between the intervention groups on any demographic characteristics, as measured at baseline (Table 1). Median age was 36.3 years and the median years of education were 12.0, indicating that most had completed secondary school. Based on Polynesian BMI cut offs, the median BMI for all groups (36.9) was in the obese range (BMI $\geq$32.0 kg/m^2).[3]

Table 1: Sample Characteristics

	Overall Median (Q1, Q3), n (%)	FitBit Only Median (Q1, Q3) , n (%)	Scale Only Median (Q1, Q3) , n (%)	FitBit and Scale Median (Q1, Q3) , n (%)	P-Value[1]
	n=44	*n=15*	*n=14*	*n=15*	
Age (years)	36.3 (34.0, 38.4)	37.4 (33.6, 39.2)	36.1 (33.5, 39.0)	36.2 (34.3, 37.8)	0.847
Education (years)	12.0 (12.0, 13.0)	12.0 (11.0, 13.0)	13.0 (12.0, 13.0)	12.0 (12.0, 13.0)	0.428
Marital Status (married)	35 (79.6)	10 (66.7)	11 (78.6)	14 (93.3)	0.420
Number of Biological Children	4.0 (3.0, 5.5)	5.0 (3.0, 6.0)	5.0 (3.0, 6.0)	3.0 (2.0, 4.0)	0.130
	n=40	*n=11*	*n=14*	*n=15*	
Body Mass Index (kg/m^2)	36.9 (33.9, 40.1)	36.9 (27.9, 39.6)	36.2 (34.4, 39.9)	37.0 (34.4, 46.9)	0.420

[1] P-values reflect Kruskal-Wallis test for continuous variables and Fisher's Exact test for categorical variables. Sample size varies due to missing data.

Device Use

Among all participants, there was a significant decline in use of the FitBits between the baseline period, when no groups received feedback, and during the intervention period (66.7% vs. 47.2% of days, p<0.001) (Table 2). There was no significant difference in use between the three groups during either of these time periods. Participants made a median of 5.5 scale measurements during the 4 weeks of use, with a minimum of 1 measurement and a maximum of 26 measurements. There was no significant difference in scale use between the two groups that received scales, indicating that feedback about physical activity did not significantly affect the frequency of self-weighing (p=0.277).

Table 2: Device Use

	FitBit Use[1] Median (Q1, Q3)					**Scale Use**[2] Median (Q1, Q3)
	Baseline Period	Intervention Period	Change	P-Value[3]		
Overall *n=44*	66.7 (50.0, 83.3)	47.2 (31.5, 72.2)	-0.15 (-0.31, -0.01)	<0.001	*n=28*	5.5 (3.0, 7.0)
FitBit Only *n=15*	66.7 (50.0, 83.3)	40.7 (35.7, 57.1)	-0.11 (-0.30, -0.04)	0.010		-
Scale Only *n=14*	83.3 (50.0, 83.3)	53.7 (29.6, 70.4)	-0.17 (-0.30, 0.02)	0.042	*n=14*	5.0 (2.0, 7.0)
FitBit and Scale *n=15*	83.3 (50.0, 83.3)	50.0 (14.8, 77.8)	-0.17 (-0.39, 0.06)	0.035	*n=14*	6.0 (4.0, 7.0)

Median (Q1, Q3) Sample size varies due to missing data.
[1] FitBit use was defined as the proportion of days in the given period that the individual participant wore the FitBit. A day was counted as a day of use if the FitBit recorded more than 100 steps. This measure for the intervention includes the groups who received feedback from the FitBit and the one group who did not.
[2] Scale use was defined as the number of measurements than an individual made on the BodyTrace during the 4-week intervention period.
[3] P-values reflect the Kruskal-Wallis test

Psychosocial Indicators of Health

Following the intervention, there was a significant different in psychosocial indicators of health (Table 3). The median score on each of the HLOC subscales increased by a statistically significant amount during the intervention period in the Scale Only, and the combined FitBit and Scale groups, indicating a greater perception of the influence of the specific locus of control on health. The FitBit Only group had a significant increase in the Chance and Powerful Others subscales, but no significant change in the Internal subscale, potentially due to a higher starting score. After the intervention period there was no statistically significant difference between the groups for any of the HLOC subscales. Participants in all three groups had a significant increase in Self-efficacy for Exercise following the intervention, with a median increase of 16.0 across all three groups. The FitBit Only and FitBit and Scale groups had a significant increase in Weight-Control Self Efficacy following the intervention of 18.0 and 14.0 respectively, while the Scale Only group increased by 12.0 (p=0.053).

There was a significant difference in how the groups' self-assessments of health changed during the intervention period. While the FitBit Only group reported significantly improved quality of life related to physical (2.5 to 6.5, p=0.002) and mental health (3.0 to 6.0, p=0.008) using the SF-8 Quality of Life scale, the Scale Only group significantly decreased in their assessment of their mental health quality of life (4.0 to 1.0, p=0.041). There was no significant change in the FitBit and Scale group's assessments of their physical or mental health. All participants reported that their health was excellent, very good, or good pre-randomization and post-intervention. However, post-intervention there were significant associations between intervention groups and self-reported health status, using Fisher's exact test (p=0.038). The proportion of individuals in the FitBit only group reporting that their health was excellent increased (from 73.3% to 86.7%), while the proportion decreased for the Scale Only (64.3% to 57.1%) and FitBit and Scale groups (80.0% to 33.3%).

Table 3: Psychosocial Indicators of Health

	Initial Score	**Change in Score** Median (Q1, Q3)			
	Overall Median (Q1, Q3)	Overall	FitBit Only	Scale Only	FitBit and Scale
Health Locus of Control	*n=38*	*n=38*	*n=11*	*n=13*	*n=14*
Internal	26.0 (21.0, 31.0)	*8.0 (3.0, 15.0)	3.0 (-3.0, 5.0)	*10.0 (9.0, 15.0)	*13.5 (8.0, 17.0)
Chance	14.0 (11.0, 21.0)	*19.0 (12.0, 24.0)	*21.0 (11.0, 24.0)	*16.0 (10.0, 24.0)	*19.0 (15.0, 25.0)
Powerful Others	24.5 (19.0, 28.0)	*10.0 (4.0, 15.0)	*8.0 (-1.0, 14.0)	*8.0 (4.0, 12.0)	*10.5 (8.0, 18.0)
Self-Efficacy					
Self-efficacy for Exercise	*n=39*	*n=39*	*n=14*	*n=13*	*n=12*
	44.0 (24.0, 60.0)	*16.0 (0.0, 32.0)	*22.0 (0.0, 28.0)	*8.0 (0.0, 32.0)	*8.0 (0.0 42.0)
Weight Efficacy	*n=33*	*n=33*	*n=12*	*n=11*	*n=10*
	76.0 (68.0, 88.0)	*16.0 (4.0, 28.0)	*18.0 (12.0, 30.0)	12.0 (4.0, 28.0)	*14.0 (4.0, 40.0)
SF8 Quality of Life	*n=38*	*n=38*	*n=14*	*n=11*	*n=13*
Physical Component Score	2.0 (2.0, 3.0)	*1.0 (-1.0, 4.0)	*3.5 (0.0, 6.0)	0.0 (-1.0, 1.0)	1.0 (-1.0, 3.0)
Mental Component Score	3.0 (1.0, 4.0)	0.0 (-2.0, 3.0)	*2.0 (1.0, 7.0)	*-2.0 (-7.0, -1.0)	0.0 (-3.0, 1.0)
		Overall n (%)	FitBit Only n (%)	Scale Only n (%)	FitBit and Scale n (%)
Self-Reported Health		*n=44*	*n=15*	*n=14*	*n=15*
	Initial (Excellent)	32 (72.7)	11 (73.3)	9 (64.3)	12 (80.0)
	Final (Excellent)	26 (59.1)	13 (86.7)	8 (57.1)	5 (33.3)

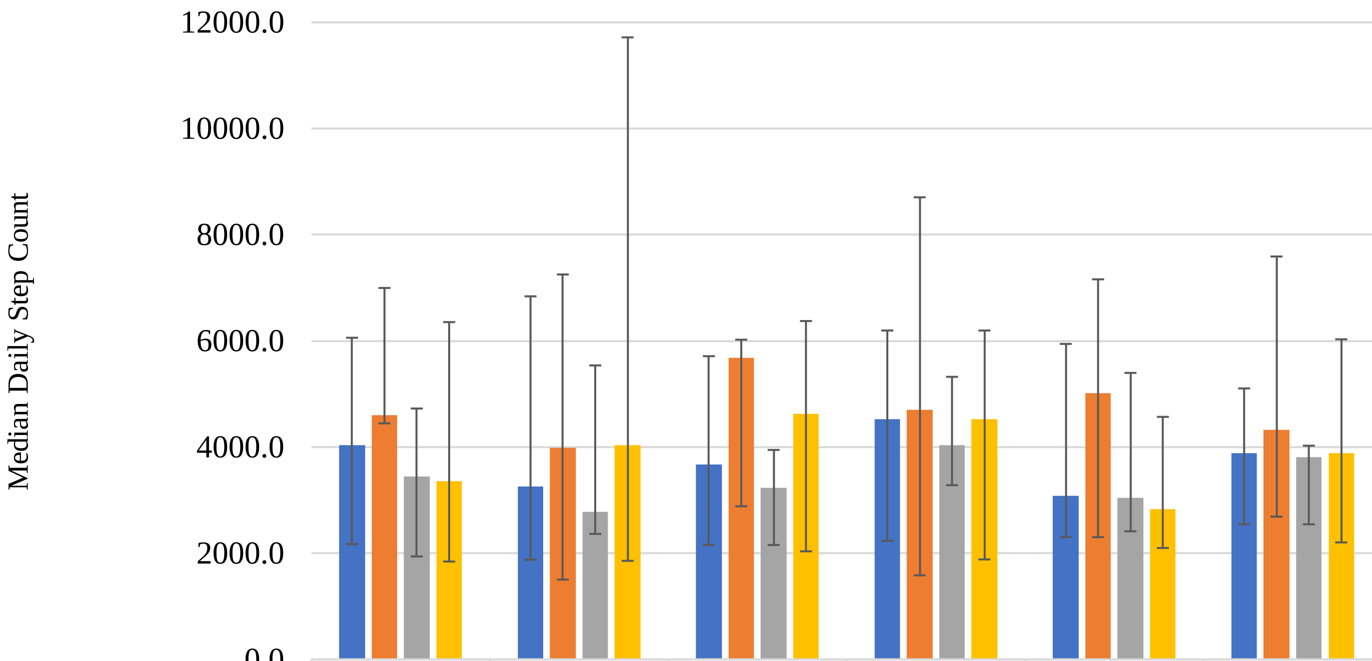
* Indicates that the change in score is statistically significant at alpha = 0.05, using the Wilcoxon Signed-Rank test

Physical Activity

There was no clear effect of the intervention on physical activity, measured using the median daily step counts for the baseline period and each week of the intervention period (Figure

2). Although not significant, the Scale feedback Only and the combined FitBit and Scale groups saw an increase in steps between the baseline and overall intervention periods.

Figure 2: Median Daily Step Count by Intervention Period



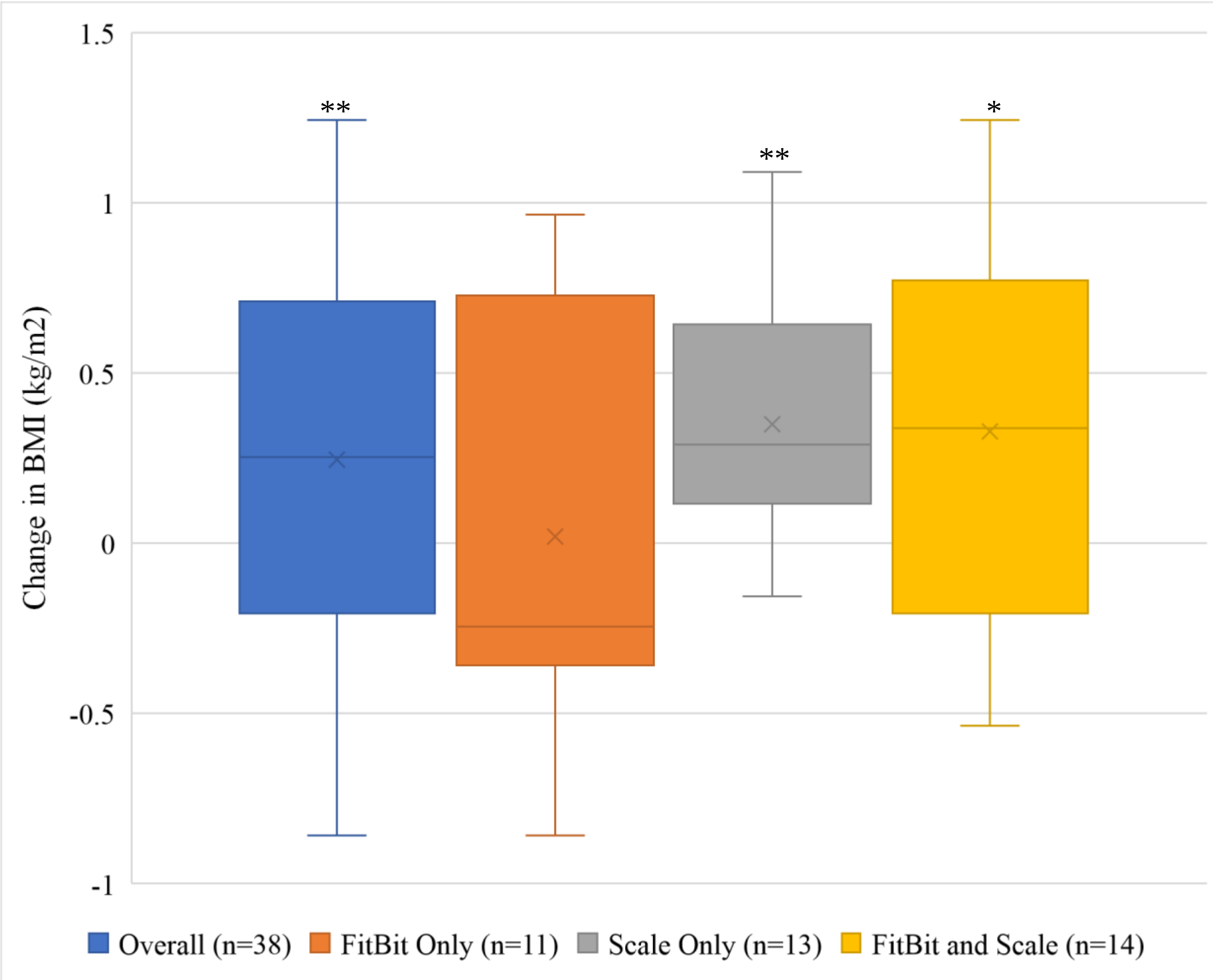
	Baseline	Week 1	Week 2	Week 3	Week 4	Intervention
Overall (n=23)	4039.5	3254.3	3672.3	4526.9	3085.2	3886.1
FitBit Only (n=7)	4598.7	3985.6	5683.0	4696.3	5010.3	4317.8
Scale Only (n=9)	3444.4	2776.7	3236.6	4034.0	3042.7	3811.1
FitBit and Scale (n=7)	3359.7	4030.3	4625.3	4526.9	2825.3	3886.1

Error bars represent the interquartile range.
Participants were excluded from the step count analysis if they were missing data for an entire week, either due to non-adherence, loss of the FitBit, or a device malfunction.

Body Mass Index

There was no significant difference between the median BMI in each of the groups at either of the time points, or in the median change in BMI (Figure 3). However, the groups that used scales had a significant increase in BMI (Scale Only p=0.005, FitBit and Scale p=0.058), while the FitBit Only group had a slight, nonsignificant decrease in BMI. There was not a significant correlation between number of measurements and BMI change.

Figure 3: Change in Body Mass Index by Group



** indicates statistically median change at p=0.05, * indicates a statistically significant median change at p=0.10; p-values reflect the result of the Signed Rank Test

Discussion

Although they have proven effective in high-income settings, self-monitoring devices such as step counters and scales have not been widely tested in low and middle-income settings such as Samoa. Our results suggest that FitBit step counters and digital scales are an acceptable intervention tool that had a promising impact on psychosocial indicators of health. However, further research is necessary to encourage long-term adherence to device use and to determine how to effectively encourage behavior change.

Device Use

Participants made use of the scales that they were assigned to use, with most participants using the scale more than once per week. No specific guidance was given to participants about how frequently they should weigh themselves, so this high usage suggests interest. Regular self-weighing is associated with weight loss, with some weight loss interventions recommending daily self-weighing.[10] However, this daily focus on weight can have a negative impact on psychosocial health.[28] The weekly frequency at which most participants in this study weighed themselves would have been sufficient for them to observe the overall trend in their weight if they were to continue this behavior over a longer intervention period, which is the aim of the self-weighing approach.

While FitBit use was high during the baseline period, adherence to daily wear declined in all three groups during the intervention. In our analyses of changes in daily step counts almost half of the sample had to be excluded due to low adherence, which is of concern. A study conducted in New Zealand in 2016-2017 enrolled Maori and Pacific Islanders in a team based weight loss competition.[29] While those teams that consistently completed these challenges experienced positive anthropometric changes, there was a significant decline in adherence to the daily competition activities during the trail, with only 5 of the 19 teams maintaining these activities over the full 24 weeks. This result suggests that long term retention and adherence in these kinds of intervention are a challenge that warrants further research. In a 2015 study conducted in California among overweight and obese post-menopausal women, participant usage of a FitBit activity monitor occurred on a median of 95% of days over the 16 week study period.[30] That study involved a structured intervention and a website based platform, which may have provided participants with more regular encouragement and engagement to maintain device use than our pilot study. The decline in adherence we observed indicates that while participants were open to using the devices, further research is necessary to determine how best to encourage continued adherence to wearing the FitBit. One potential strategy would be to utilize a wrist worn model of FitBit, which might be less easily removed or forgotten than the waist worn model selected for this study.

Psychosocial Indicators of Health

Health Locus of Control (HLOC) has been identified as an important indicator related to health behaviors. Individuals with a higher internal locus of control were more likely to stop smoking than those who had a higher external locus of control, including chance and other people, and more likely to engage in health promoting behaviors.[31] In all groups participants increased in their assessments of HLOC.[25] The fact that participants increased their scores on all three of the HLOC subscales suggests that participants felt simultaneously more in control of their own health, but also more aware of the influence of outside forces, including chance and other people, on their health. Participation may have highlighted the ways that they can influence their own health, while also making them aware of the external factors. In a sample of Samoan women of a similar age (n=39), median HLOC subscale scores were: internal 30.0 (29.0, 33.0), chance 25.0 (23.0, 27.0), and powerful others 29.0 (27.0, 31.0).[32] When compared to this similarly aged sample, this pilot study's participants had significantly lower initial scores in each subscale and significantly higher final scores following the intervention period, suggesting the potential benefit of this intervention.

Participants in all groups also improved their assessments of Self-Efficacy for Exercise and Weight Efficacy.[26,27] Self-efficacy has been identified as essential for helping individuals who intend to make health behavior changes to follow through on these intentions. A 2005 study found that self-efficacy mediated the association between exercise intentions and physical activity among cardiac rehabilitation patients.[33] Self-efficacy could therefore be a valuable target for interventions aiming to improve physical activity. In a 1997 study, sedentary adult patients at a physician's office were randomly assigned to receive behavioral counseling to improve self-efficacy. Self-efficacy was significantly associated with both self-reported and objectively measured physical activity.[34] For this reason the significant increase in self efficacy among all participants is a promising finding, despite the lack of a clear finding related to behavior change.

While the FitBit Only group reported improved self-reported health status and mental and physical health related quality of life, the groups that used the scales decreased or did not significantly change these assessments. This indicates that there may have been a negative impact of the scale feedback on participant's mental or perceived health. One possible explanation for this difference is that the step count feedback that the FitBit displayed was relatively easily modifiable if participants were not satisfied. In contrast, using a scale for four weeks may have made participants more aware of their weight, which is not as easily changed during such a short time frame. As a result, participants may have felt discouraged, resulting in the worsened outcomes related to these self-assessments of health. Self-monitoring of weight has been identified as a "double-edged sword"; it is an effective tool for interventions, but can also worsen body image concerns in a way that might undermine progress.[28] How individuals in Samoa use and react to the feedback that these devices provide is an important area for further research to determine how to most effectively design interventions. It is also important to note that the greatest decline in self-reported health status occurred for the FitBit and Scale group, which may suggest that they received an overwhelming amount of information that was difficult to manage.

Physical Activity

There was no clear change in daily step counts between the baseline and intervention periods. Although the median step counts varied between the baseline and intervention period, the small sample size and high variability within the groups limited the statistical power of these analyses. Step analyses were restricted to participants who recorded at least one day of use in each of the weeks of the study, which excluded approximately half of participants as a result of declines in adherence and the loss of devices. Interpretation of these results is also limited by the fact that it is not possible to determine if a decrease in step count is due to a decline in device usage or to a decline in physical activity. Given the significant decline in adherence that occurred, this potential measurement issue is a concern. Future studies could incentivize continued adherence and select an alternate device that would better enable the distinction between device usage and inactivity, as is possible with device models that utilize heart rate tracking.

Body Mass Index

The median change in BMI in the overall sample was positive and significant. There was no significant difference in BMI change between the groups. However, while the two scale groups saw a significant increase in BMI, there was a non-significant decrease for the FitBit Only group. This pattern mirrors the difference observed with the self-reported health status and SF8 Quality of Life scales and suggests a more positive impact of FitBit feedback than that of the scale. That participants' BMI significantly increased during the 4-week intervention period is concerning. Even using the self-monitoring devices and with a population that indicated they were motivated to become more physically active, the median increase in weight during the study for the overall sample was 0.70kg, or approximately 9.10kg per year. This increase in BMI underscores the critical need for effective weight control interventions in this setting.

Limitations

This pilot study took an innovative approach to evaluate the acceptability, feasibility, and potential effectiveness of self-monitoring devices in Samoa. However, there are important limitations of its design that are important to consider. The small sample size and large degree of variability in the sample limited the power of analyses to identify a clear pattern in behavior, if one existed. Additionally, these analyses were limited by a significant decline in adherence to device use and our inability to differentiate a decline in adherence from a decline in physical activity. Using 100 steps as the cutoff to establish a day of device wear was a reasoned but ultimately arbitrary decision. Future studies could address these limitations by using a wrist worn model of FitBit that included heart rate tracking to better establish participant use.

This study was designed as a pre/post comparison, with individual behaviors during the intervention period compared to the individual's baseline values. While there is no evidence to suggest that there was a population wide change during this study period, the lack of a control group is another potential limitation of this design. As a feasibility study, the included intervention was not framed around specific physical activity or weight loss goals. This approach was taken to explore how participants in this setting used these devices in the absence of other guidance. However, the lack of a change to step counts may be in part the result of this approach. Despite these limitations, the novel data provided by this study have value in suggesting the feasibility and possible efficacy of self-monitoring devices for interventions in Samoa, and potentially other LMIC.

Conclusions

Given the expanding access to mobile technologies in LMIC, this is an ideal moment to introduce the self-monitoring technologies and intervention approaches that have proven effective in high-income countries to these new settings in the hope of addressing the rising burden of obesity and NCDs. The results of this study suggest that FitBit step counters and digital scales are an acceptable and potentially effective tool for interventions to utilize in the Samoan setting. Additionally, the increase in BMI that occurred over the relatively short study period reinforces the need for weight control interventions in this setting. While no significant difference was observed in participant's physical activity, improvements to psychosocial indicators of health suggest a positive effect of using these devices. Further research is warranted to explore the potentially negative impact of scale feedback, how to sustain device usage over time, and to evaluate the effect of these devices on physical activity and weight in a more structured intervention setting.

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